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[54] **CABLE ACCESS DEVICE AND METHOD**

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[51] **Int. Cl.**[6] **H04N 7/10**

[52] **U.S. Cl.** **455/3.3**; 348/6; 348/12; 455/3.3; 323/282; 363/21; 363/41; 363/47

[58] **Field of Search** 323/282; 363/21, 363/41, 97; 455/3.1, 3.2, 3.3, 4.1, 4.2, 5.1, 6.1, 6.2; 348/6, 7, 8, 10, 12, 13

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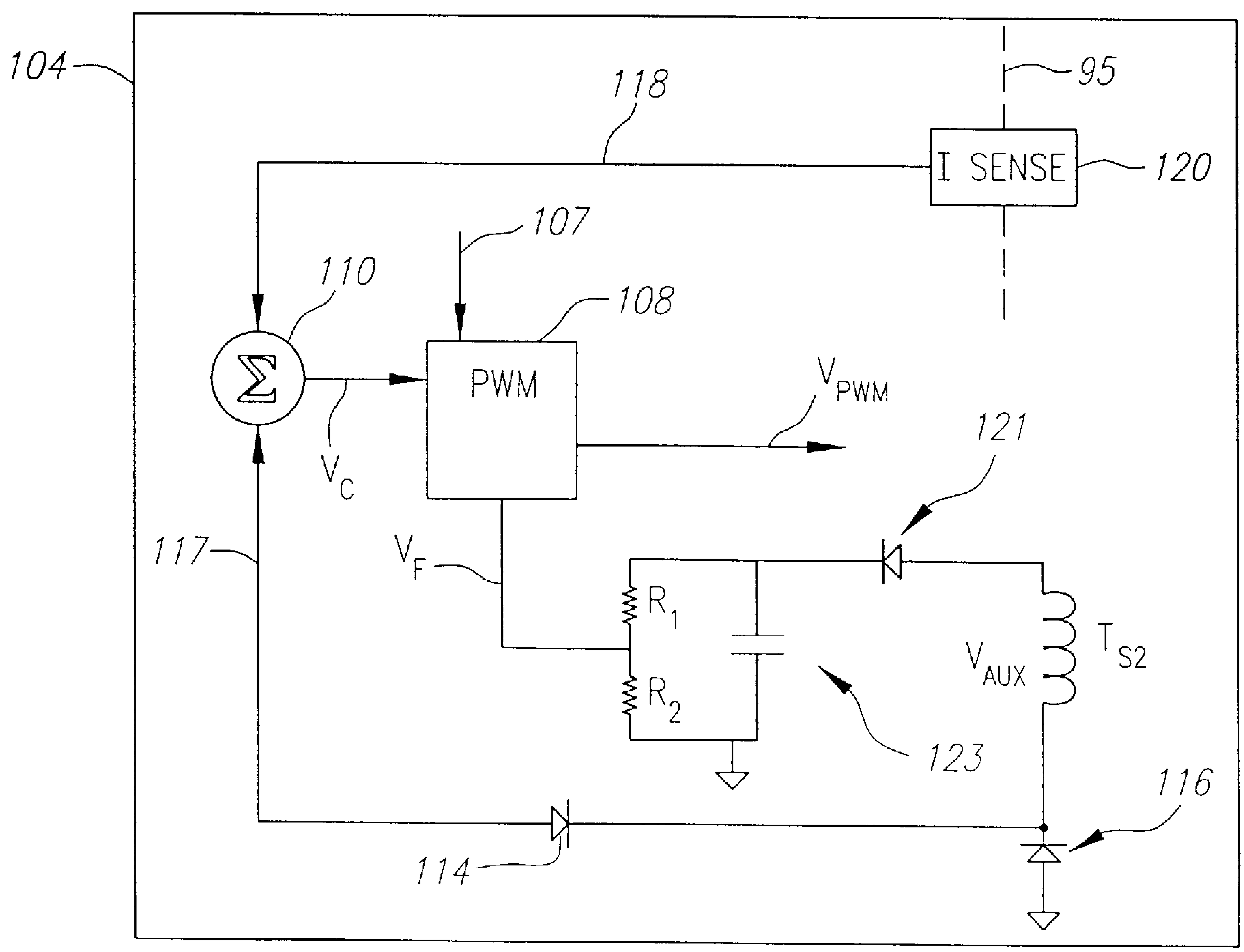
Attorney, Agent, or Firm—Lyon & Lyon LLP

[57] **ABSTRACT**

An access device having an input port for connecting to an upstream section of a coaxial distribution cable and an output port for connecting to a downstream section of a coaxial distribution cable, and provides isolation of an RF communication signal from an AC power signal for access by subscriber network service equipment. The access device also includes power conditioning of the AC signal to provide a DC operating voltage over a separate output to operate the respective subscriber network service equipment.

19 Claims, 4 Drawing Sheets



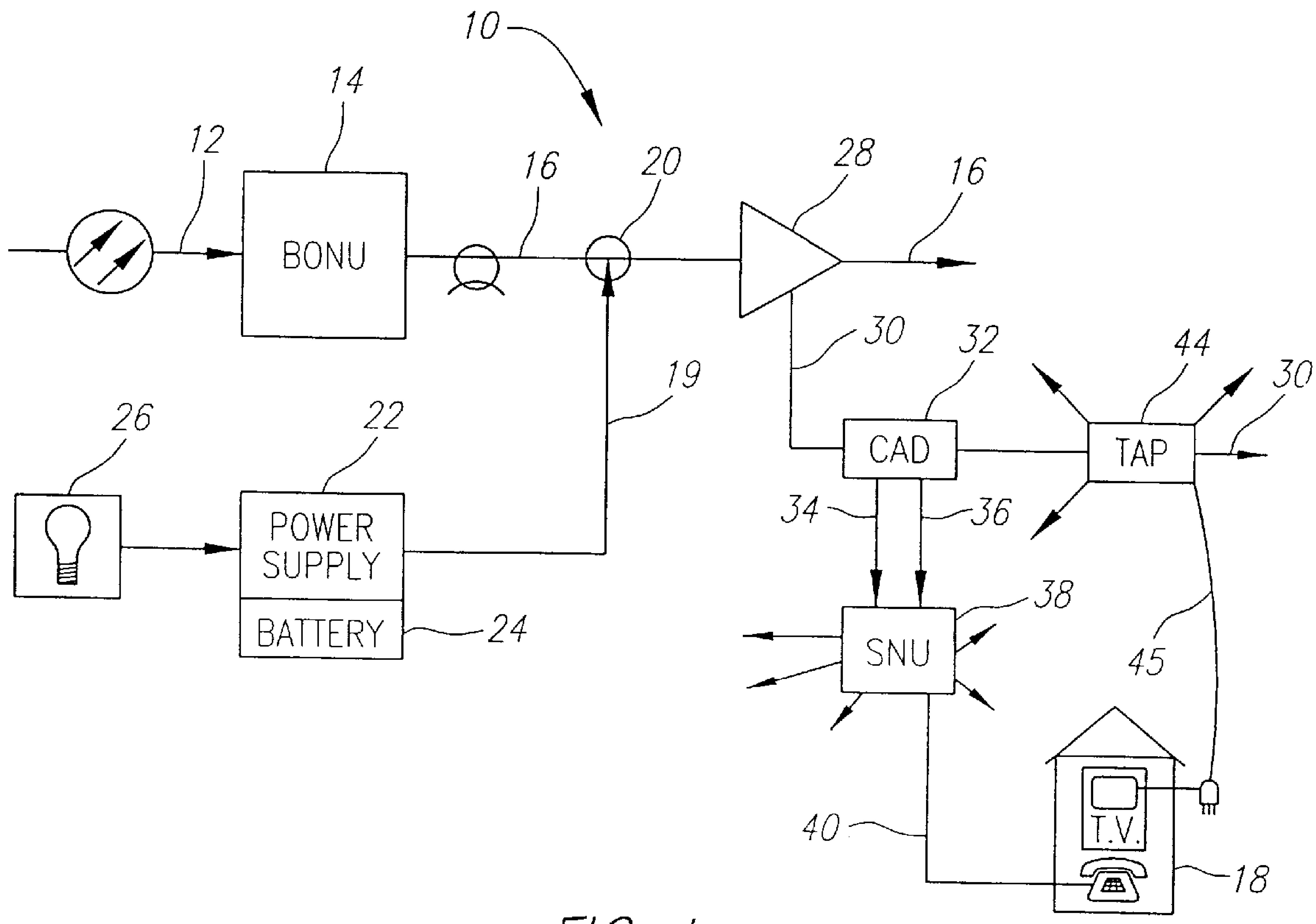
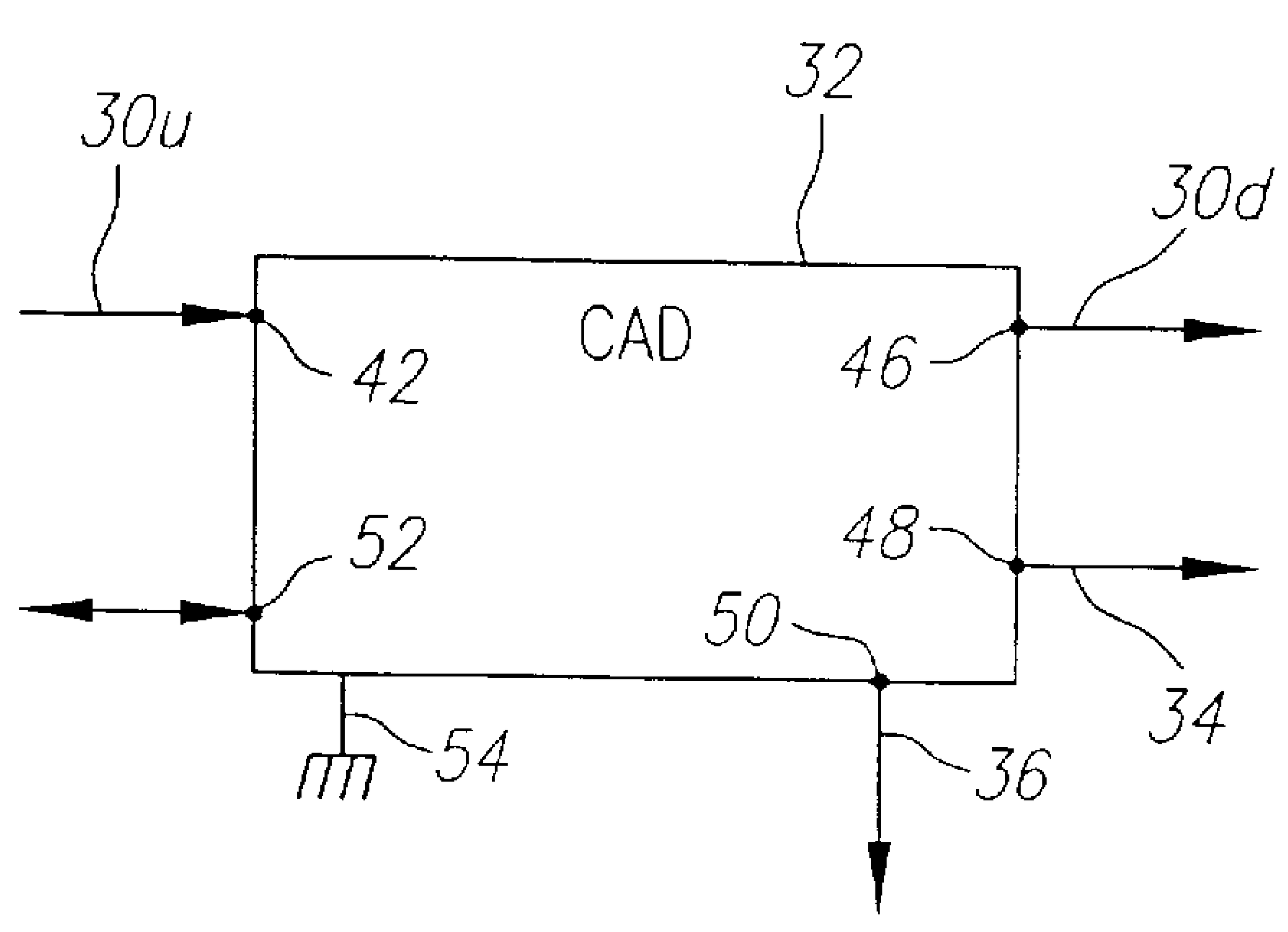

10
14
12
BONU
16
20
28
16
30
32
44
30
19
26
22
CAD
TAP
POWER
SUPPLY
34
36
BATTERY
24
38
SNU
45
40
T.V.
18

FIG. 1


32
30u
30d
CAD
42
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52
48
50
34
54
36

FIG. 2

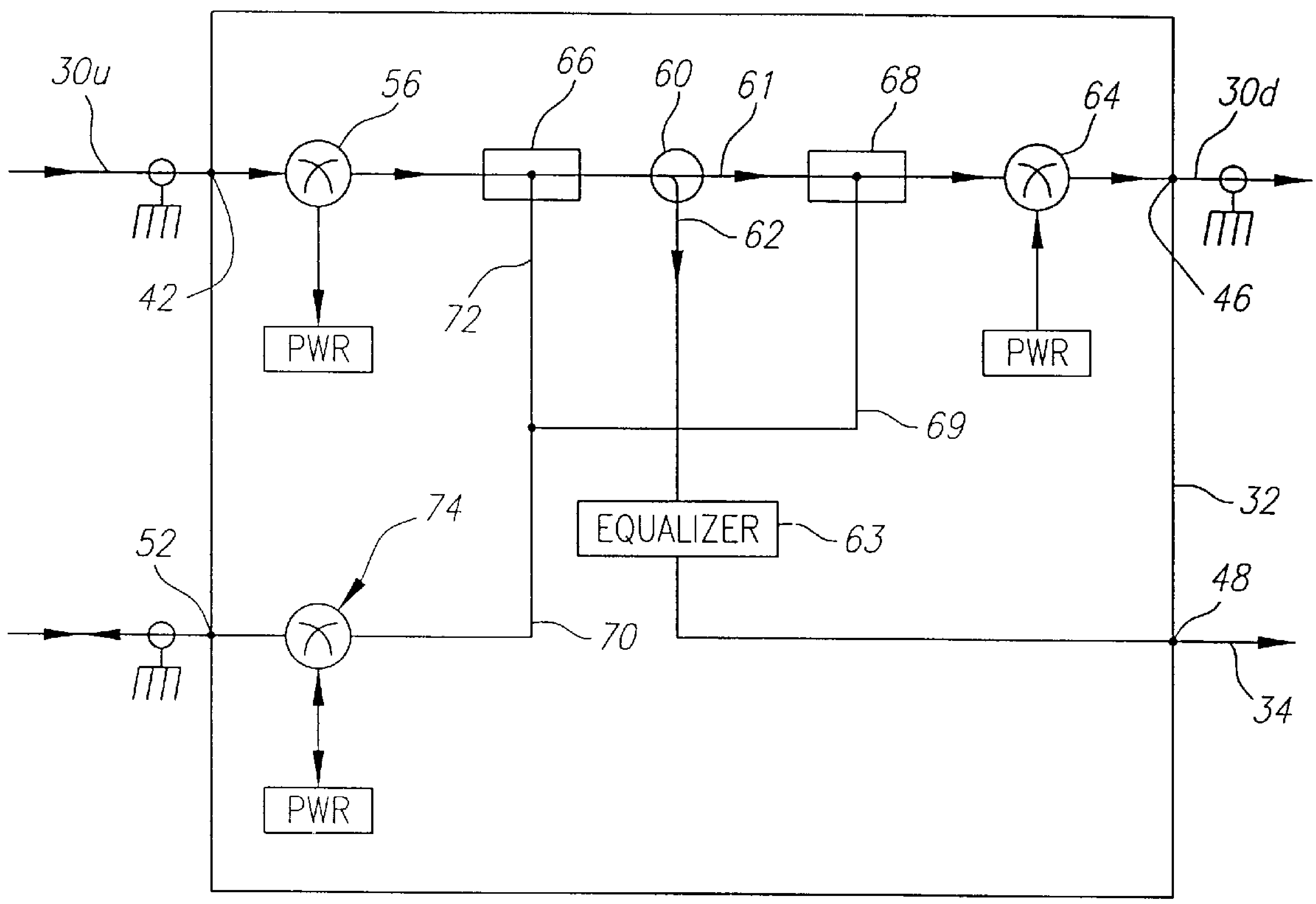
30u
56
66
60
61
68
64
30d
42
72
62
46
PWR
PWR
69
32
74
EQUALIZER
63
52
48
70
34
PWR

FIG. 3

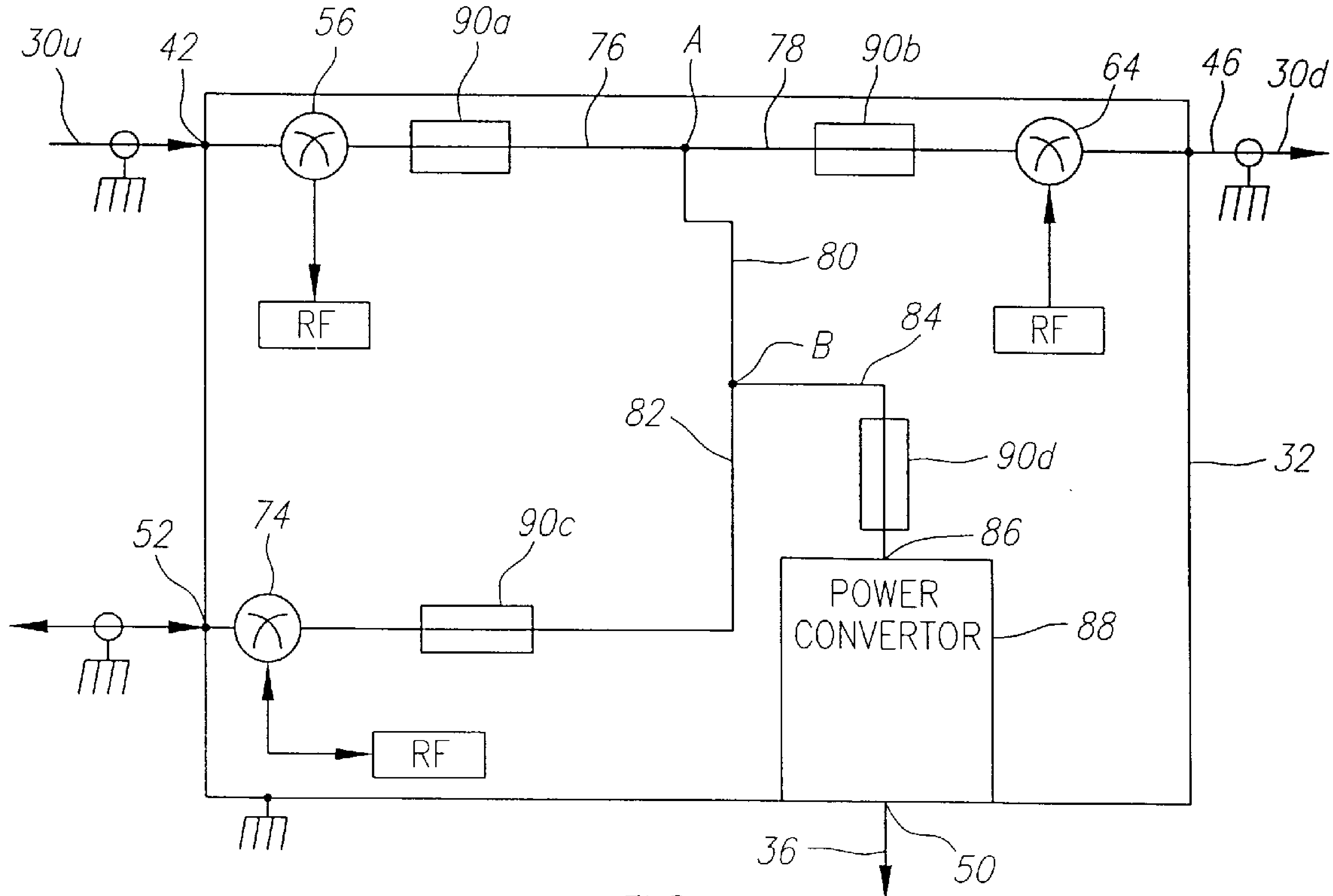
30u
42
56
90a
76
A
78
90b
64
46
30d
80
RF
84
RF
B
82
90d
32
52
74
90c
86
POWER CONVERTOR
88
RF
36
50

FIG. 4

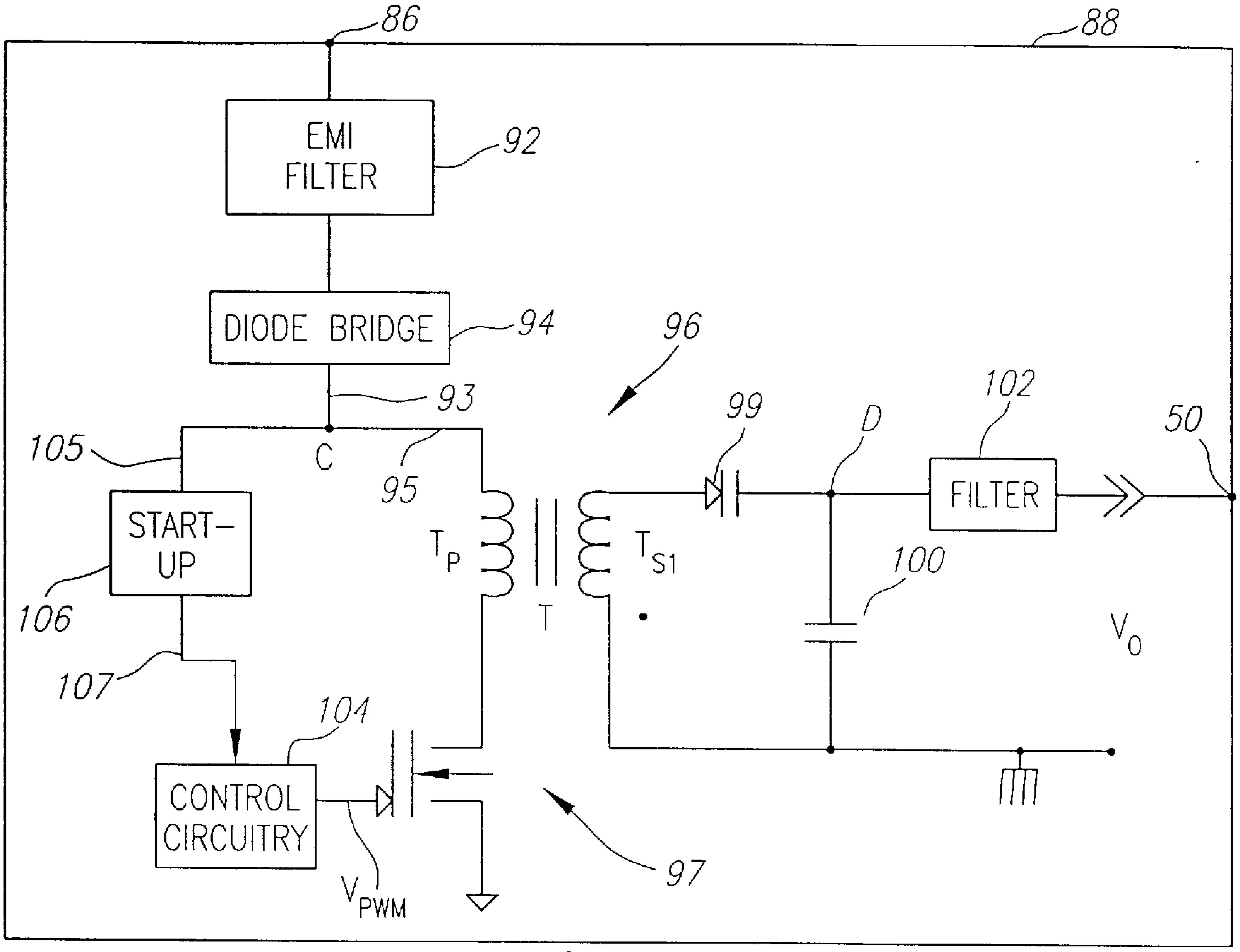
86
88
EMI FILTER
92
DIODE BRIDGE
94
96
93
99
D
102
50
105
C
95
START-UP
T
P
T
S1
FILTER
100
106
T
V
0
107
104
CONTROL CIRCUITRY
V
PWM
97

FIG. 5

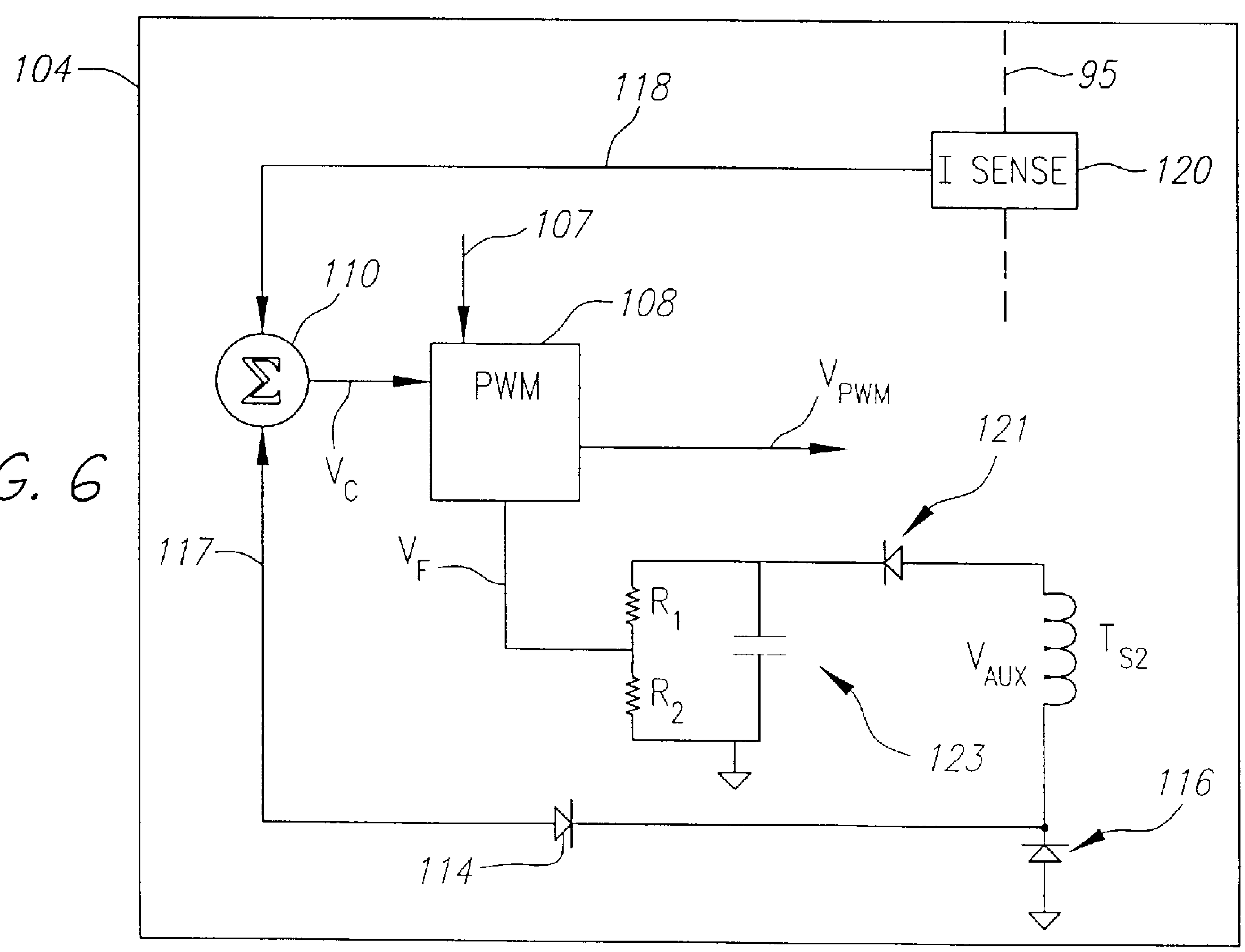
104
118
95
I SENSE
120
107
110
108
PWM
V
PWM
V
C
121
117
V
F
R
1
R
2
V
AUX
T
S2
123
116
114

FIG. 6

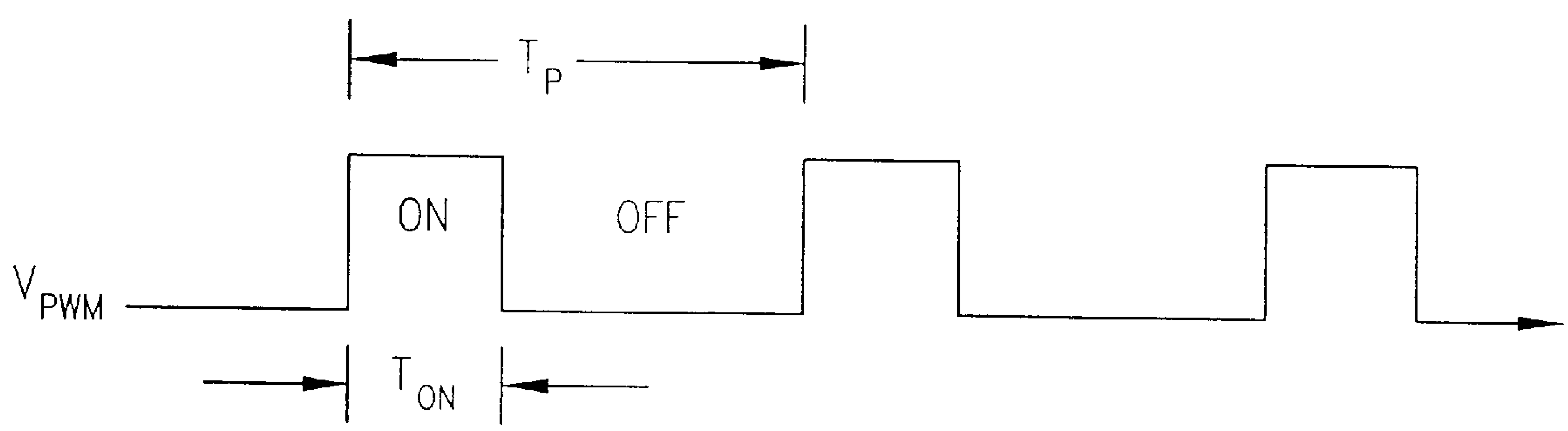

FIG. 7

CABLE ACCESS DEVICE AND METHOD

FIELD OF THE INVENTION

The present invention pertains to the field of communication networks, including methods and apparatus for providing access to communication and electrical power signals carried over a distribution cable.

BACKGROUND OF THE INVENTION

In most modern telecommunication networks, a community of subscribers are connected to a central office switch through a "two-way" distribution network, which may include one or more transmission facilities, e.g., microwave, optical, electrical, etc., and which may utilize both digital baseband and analog transmission protocols.

By way of example, subscribers associated with a particular central office switch may be connected to the switch via a series of remotely located subscriber network units, with each subscriber network unit serving subscribers in a defined local area. Between the central office switch and each subscriber network unit, telecommunication signals are commonly digitized and multiplexed for transport over relatively high bandwidth facilities, e.g., optical fiber, for greater network efficiency. At the subscriber network unit, individual subscriber signals are typically de-multiplexed and terminated on respective "line cards," which generally perform certain functions such as digital-to-analog conversion and power regulation, e.g., for dial tone, ringing, off-hook detection, etc., that were traditionally performed at the central office. The respective line cards are connected to individual subscriber lines, e.g., twisted wire pairs, for transport of the subscriber signals to and from the respective subscriber premise locations. At the subscriber premise location, the subscriber line is normally terminated on a "network interface" device, e.g., in an environmentally secured enclosure mounted on an exterior wall of a house, or in a "telecommunications closet" serving one or more floors of an office building, respectively. In particular, the network interface device is the termination point for connecting the subscriber's telecommunication equipment, e.g., telephone sets and/or computer modems, to the distribution network.

In many, if not all modern video broadcast networks, e.g., a cable television ("CATV") broadcast network, a broadcast communication signal is transmitted "downstream" from a headend broadcast facility to a community of subscribers over a broadcast distribution network. As with the aforedescribed telecommunication distribution network, a CATV broadcast distribution network may include one or more transmission facilities, e.g., optical and/or electrical, and may utilize differing transmission protocols, e.g., analog RF and/or digital baseband. By way of example, an analog RF CATV broadcast signal may be transmitted optically from a headend facility to a series of distributed hub locations, each of which splits (and amplifies) the broadcast signal for further downstream optical transmission over a number of "branch" facilities to a series of remotely located "broadband optical network units" ("BONUs"). At the BONU, the CATV broadcast signal is typically converted from optical to RF electrical transmission and delivered via electrical RF carrier over a coaxial distribution cable to respective subscriber premise locations served by the BONU. A coaxial splitter (or "tap") device can be used to allow the CATV broadcast signal to be provided onto a subscriber coax drop cable, which distributes the broadcast signal to one or more television sets within the respective subscriber premise location.

It has become desirable to be able to reduce the required transmission facilities for telecommunication and video broadcast distribution networks. In particular, it is desirable to be able to combine the delivery of, at least, two-way telecommunication signals along with a CATV broadcast signal for transmission over the same distribution network. For example, "downstream" optical telecommunication signals may be combined with downstream optical CATV broadcast signals at the aforedescribed BONU locations, wherein the signals are modulated as a "composite" electrical RF communication signal for further downstream distribution over a coaxial cable. However, a combined CATV and telecommunication distribution network faces certain design obstacles. For example, network components, such as, e.g., periodic signal amplifiers or the aforedescribed subscriber network units, respectively, require operating power, preferably supplied over the same distribution network as the communication signals. At the same time, for safety reasons, the communication signals must be accessible at the respective subscriber network units, i.e., without the power signal being present.

It is desirable, therefore, to be able to provide an access device for obtaining both RF communication signals and electrical power signal, respectively, from a coaxial distribution cable in a combined CATV and telecommunication network, wherein the obtained signals may thereafter be transmitted over separate lines to respective subscriber equipment facilities. It is further desirable to provide conditioning of the respective power signals into suitable operating voltage supplies for the respective subscriber equipment facilities.

SUMMARY OF THE INVENTION

In a distribution network, the present invention provides an access device for supplying a relatively high frequency RF communication signal and a source of DC operating voltage derived from a relatively low frequency AC power signal for use by one or more network subscribers.

In a preferred embodiment, the access device includes a input port for connecting to an "upstream" section of a coaxial distribution cable carrying an RF communication signal and an AC power signal. A first diplexer circuit isolates the communication signal from the power signal, wherein an RF tap splits the isolated communication signal for transmission over at least first and second internal RF paths. The portion of the communication signal on the first internal RF path is re-combined with the power signal by a second diplexer circuit, wherein the combined signals are then connected to an output port for reinserting onto a "downstream" section of the coaxial distribution cable, i.e., for further downstream transmission. The portion of the communication signal on the second internal RF path is preferably attenuated to a desirable output level and supplied to a respective subscriber network unit.

In accordance with an aspect of the present invention, power converter for deriving a DC operating voltage supply from the isolated AC power signal is provided, wherein the AC power signal is rectified, e.g., by a diode bridge, and used as an input voltage for a flyback converter controlled by a variable duty cycle control circuit directing a transistor switch, e.g., a MOSFET, to periodically connect a primary winding of a transformer with the input voltage. When the switch is ON, current flows through the primary winding and energy is stored by the inductance of the transformer core. When the switch is OFF, the transformer core reverses polarity and energy stored therein is released in the form of current through a secondary winding, which supplies a DC output voltage. A load storage, or "filter" capacitor is provided to maintain the DC output voltage at a constant level, preferably sufficient to withstand momentary drop offs in the input AC power signal. In accordance with a more specific aspect of the present invention, the control circuitry independently adjusts both the duty cycle of the transistor switch and the transformer switching cycle period, respectively, of the power converter, in order to maintain sufficient output power with a single stage conversion; i.e., without requiring an initial input power factor correction.

The access device may also preferably be equipped with one or more auxiliary input/output ports, wherein each auxiliary port may be used for receiving or transmitting, respectively, combined communication and power signals off of or onto, respectively, an "alternate" coaxial distribution cable. A further diplexer circuit is preferably provided for each of the one or more auxiliary port(s) for separating or combining, respectively, the respective incoming or outgoing communication and power signals.

As will be apparent to those skilled in the art, other and further objects and advantages will appear hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate both the design and utility of preferred embodiments of the present invention, in which:

FIG. **1** is a block diagram of an exemplary coaxial distribution network;

FIG. **2** is a block diagram depicting functional inputs and outputs of an exemplary cable access device, in accordance with the present invention;

FIG. **3** is a block diagram depicting RF signal paths in an exemplary cable access device, in accordance with the present invention;

FIG. **4** is a block diagram depicting power signal paths in an exemplary cable access device, in accordance with the present invention;

FIG. **5** is a block diagram of a preferred power converter in an exemplary cable access device, depicting a power conversion power stage in accordance with the present invention;

FIG. **6** is a block diagram of control circuitry for the power converter of FIG. **5**; and

FIG. **7** depicts the period and duty cycle of a voltage signal, V_{pwm}, for controlling the switching cycle of the power converter of FIG. **5**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, a broadband distribution network **10** delivers a composite RF communication signal, including both CATV broadcast and telecommunication signals, respectively, over an optical fiber **12** to a broadband optical network unit ("BONU") **14**. At the BONU **14**, the composite RF communication signal is converted from optical to RF electrical transmission and transmitted onto a main coaxial distribution cable **16** for delivery to a plurality of subscriber premise locations **18** served by the BONU **14**. A low frequency AC power signal, e.g., 50 to 60 volts AC in preferred embodiments, is also transmitted onto the distribution cable **16** from a power supply line **19** by a power inserter **20**, in order to supply power to the various network components connected to the distribution cable **16**, including, e.g., the BONU **14**, and various downstream amplifiers. A power supply module **22**, preferably including a back-up battery system **24**, respectively, supplies the AC power signal onto power line **19**. In turn, the power supply module **22** is supplied by a power source **26**, such as, e.g., a local power utility. The back-up battery system **24** is preferably sufficient to maintain the AC power signal over the coaxial distribution cable **16** for prolonged periods of time whenever the source **26** fails or is temporarily interrupted. It should be noted, however, that even with the back-up battery system **24** in place, a momentary loss of the AC power signal (e.g., up to a full cycle) will likely occur during a switch-over from the source **26** to the back-up system **24**, e.g., for approximately 15 ms in typical power supply systems for CATV broadcast networks. Such momentary voltage losses may also occur due to measures taken at the supply module **22** to protect from transients or surges over the distribution cable **16**.

The distribution cable **16** passes through one or more amplifiers **28**, wherein the RF communication signal is amplified and split onto one or more coaxial feeder cables **30**. The AC power signal is diverted within the amplifier **28**, e.g., by means of a diplexer circuit (not shown), so that the RF communication signal can be amplified. The AC power signal is then recombined with the RF communication signal on the (downstream side of) distribution cable **16**, as well as on each of the coaxial feeder cables **30**, respectively, after the RF signal is amplified. A plurality of coaxial cable access devices ("CADs") **32** are interposed along each feeder coaxial cable **30**. In a manner described in greater detail herein, each CAD **32** isolates the RF communication signal from the AC power signal and splits off a portion of the RF signal for transport to a respective subscriber network unit **38** by way of a coaxial RF access line **34**. The subscriber network units **38** each include circuitry for deriving one or more telecommunication subscriber channels from the RF communication signal, e.g., voice and/or data channels, for delivery over respective subscriber lines **40** to a plurality of subscriber premise locations **18** served by the respective subscriber network unit **38**. For example, in a combined CATV broadcast and telecommunication distribution network employed by the assignee of the present invention, up to thirty-two subscriber lines **40** may preferably be connected to a single subscriber network unit **38**.

Each CAD **32** also includes power conditioning circuitry for converting the AC power signal to a DC operating voltage supply, e.g. −115 to −130 volts DC in preferred embodiments, for transmission over a separate access line e.g., a twisted wire pair **36**, to the respective subscriber network unit **38**. By preferably providing the RF communication signal and DC operating voltage supply over separate access lines, **34** and **36**, respectively, from the CAD **32** to the respective subscriber network unit **38**, the CAD **32** advantageously allows for the RF communication equipment (not shown) in the subscriber network unit **38** to be safely handled, e.g, by a service technician.

A plurality of conventional tap devices **44** may also be provided along each feeder cable **30**, wherein each tap **44** also isolates and splits off the RF communication signal, respectively, for transmission over one or more subscriber CATV coaxial drop cables **45**.

Referring to FIG. **2**, the CAD **32** includes an input port **42** for receiving the respective RF communication and AC power signals off of an upstream portion **30***u* of coaxial feeder cable **30**, and an output port **46** for re-inserting the respective signals back onto a downstream portion **30***d* of cable **30**, respectively, for further downstream distribution. In a manner described below, an RF output port **48** provides the RF communication signal for transport over coax access cable **34**, and a power supply output port **50** provides a (converted) DC operating voltage for transport over twisted pair **36**, respectively. An auxiliary port **52** is also provided, wherein the auxiliary port may be used as an alternate input port to port **42** for receiving the respective communication and power signals into the CAD **32**, e.g., from an alternate ("upstream") distribution cable (not shown). The auxiliary port **52** may also be used as an alternate output port to port **46** for re-inserting the respective signals from the CAD **32**, e.g., onto an alternate ("downstream") distribution cable (also not shown), respectively. An electrical ground connection **54** is also provided from the CAD **32**.

Referring to FIG. **3**, the respective RF communication and AC power signals are received off the upstream portion **30***u* of feeder cable **30** through input port **42**, wherein a first diplexer circuit **56** isolates the AC power signal from the RF communication signal. The isolated RF communication signal is then passed through a tap **60**, which splits the signal for transmission over both a first internal RF path **61** and a second internal RF path **62**, respectively. The portion of the RF communication signal transported over the first internal RF path **61** is passed through a second diplexer circuit **64**, where it is re-combined with the AC power signal, and connected to output port **46** for insertion onto the downstream portion **30***d* of the coax feeder cable **30**. The portion of the RF communication signal transported over the second internal RF path **62** is preferably passed through an equalizer circuit **63** for balance and power level attenuation, respectively, and then transmitted through RF output port **48** to the respective subscriber network unit **38**.

A pair of auxiliary configuration switches **66** and **68** are preferably provided, which may be alternately configured to employ the auxiliary input/output port **52**. In particular, a third diplexer circuit **74** is provided to either separate, or re-combine, respectively, an AC power signal from/to a respective RF communication signal received through, or transmitted from, respectively, auxiliary port **52**. For example, when using (main) input port **42**, switch **66** is positioned to connect diplexer **56** to tap **60**, (as shown in FIG. **3**). Alternately, when using auxiliary port **52** as the input port, (i.e., instead of port **42**), switch **66** is positioned to connect diplexer **74** to tap **60**, via internal paths **70** and **72**, respectively. Likewise, when using (main) output port **46**, switch **68** is positioned (as shown in FIG. **3**) to connect the first internal RF path **61** to diplexer **64**, whereas when using auxiliary port **52** as the output port, switch **68** is positioned to connect diplexer **74** to the first internal RF path **61**, via internal paths **69** and **70**, respectively. It should be noted that the illustrated preferred embodiment is merely exemplary of the possible alternative input and output port configurations that are possible within the CAD **32**. By way of example only, with the teaching provided herein, one skilled in the art could employ internal switch configurations supporting multiple input and output ports, respectively, depending on a desired distribution network flexibility.

Referring to FIG. **4**, an internal power bus arrangement comprises a first node "A" and a second node "B", which connect power bus paths **76**, **78**, **80**, **82** and **84**, respectively. In this manner, the "power side" connections of respective diplexer circuits **56**, **64** and **74**, respectively, may be electrically connected. In particular, the AC power signal may preferably be throughput from a selected input port to a selected output port, regardless of whether the afore-described input/output port configuration is **42**/**46**, **42**/**52**, or **52**/**46**, respectively. For example, in the illustrated preferred embodiment, the isolated AC signal may be transmitted from port **42** to port **46**, via paths **76** and **78**; from port **42** to port **52**, via paths **76**, **80** and **82**; or from port **52** to port **46** via paths **82**, **80** and **78**, respectively. The isolated AC power signal is also preferably supplied, via node "B" and path **84**, respectively, as an input voltage **86** to a power converter **88**. The power converter **88** converts (or "conditions") the AC input signal **86** into a DC operating voltage supply, which is output through power supply output port **50** onto access line **36**, respectively, for use by a respective subscriber network unit **38**. For purposes of surge protection and selective power routing within the CAD **32**, fuses **90***a–d* are preferably interposed along the respective power bus paths **76**, **78**, **82** and **84**.

Referring to FIG. **5**, the AC input power signal **86** is passed through an electro-magnetic interference (EMI) noise filter **92** and rectified to a "DC" signal **93**, by a diode bridge **94**. The rectified "DC" voltage **93** is then supplied, by way of node "C", as an input voltage **95** for a flyback converter circuit, which includes a transformer **96** having a primary winding T_p, a transformer core T and a secondary winding T_s, respectively. To operate the converter, a transistor switch **97**, e.g., a MOSFET, is provided to periodically connect the input voltage **95** through the primary winding T_p. The switch **97** is alternately caused to be turned ON and OFF by a PWM voltage control signal, V_{pwm}, which is supplied by converter control circuitry **104**.

In particular, when V_{pwm} is "high", the switch **97** is turned ON, current flows through the primary winding T_p and energy is stored by the inductance of the transformer core T, respectively. When V_{pwm} is "low", the switch **97** is turned OFF, the transformer core T reverses polarity and stored energy is released in the form of a current through the secondary winding T_s. The released current through T_s causes a secondary rectifying diode **99** to forward bias, resulting in an output voltage V_o supplied across the power supply output port **50**, as determined by the selected turns ratio of the respective transformer windings, T_p/T_s, respectively. The output voltage V_o supplied by the direct current released through the secondary winding T_s is preferably regulated by a filter circuit **102**.

A load storage, or "hold-up" capacitor **100** is also preferably provided, by way of a node "D", after rectifying diode **99**, respectively, to maintain the output voltage V_o at a constant level between power transfer cycles of the transformer **96**. When the load storage capacitor **100** is sufficiently charged by the secondary current flow, the rectifying diode **99** reverses bias and the capacitor **100** discharges current at a steady rate through filter **102** and output port **50**, respectively, thereby maintaining a constant supply for V_o until the next transformer transfer cycle. By preferably selecting a sufficiently large capacitor **100**, the DC output voltage V_o is advantageously maintained even if the AC input voltage **86** is momentarily interrupted.

In the illustrated preferred embodiment, the rectified ("DC") voltage at node "C" is also supplied, via path **105**, to a "start-up" regulating circuit **106**, which provides an initial operating voltage **107** for the control circuitry **104**; i.e., for when the respective CAD **32** is first inserted along the coax feeder cable **30**. For example, in a preferred embodiment, the start-up circuit **106** includes a holding capacitor (not-shown) connected to path **105**. When the holding capacitor is sufficiently charged by the rectified "DC" voltage over path **105**, (i.e., from the diode bridge **94**), it will discharge a uniform threshold voltage **107** to the control circuitry **104**. Once the converter operation commences, operating (or "control") voltage for the control circuitry **104** is thereafter preferably provided by an auxiliary output of the transformer **96**.

Referring to FIG. **6**, the control circuitry **104** for the power converter **88** includes a PWM controller **108**, which outputs the PWM voltage control signal V_{pwm} to operate the switch **97**. When V_{pwm} is at "high" voltage, switch **97** is turned ON, causing current to be drawn through the primary winding T_p and energy stored in the core T, respectively, of transformer **96**. Conversely, when V_{pwm} is at a "low" voltage, switch **97** turns OFF and the energy stored in the transformer core T begins to transfer through the secondary winding T_s, to supply the output voltage V_o. In preferred embodiments, the characteristics of the PWM controller **108** are selected so that both the transfer cycle period, i.e., the period time elapsing during each full energy transfer cycle of the transformer **96**, "t_p" in FIG. **7**, and the duty cycle, i.e., the duration of time the signal is in a "high" voltage state during each charging portion of an energy transfer cycle, "t_{ON}" in FIG. **7**, respectively, of the voltage signal control V_{pwm}, are independently controlled.

In the illustrated preferred embodiment, the PWM controller **108** is controlled by a pair of independent input signals: a transfer cycle period control voltage, V_c, and a duty cycle feedback control voltage, V_f, respectively. In particular, the PWM controller **108** "resets" control signal V_{pwm}, i.e., begins a new transfer cycle period t_p, by setting V_{pwm} to "high" whenever V_c reaches a zero voltage level. The PWM controller **108** will then maintain V_{pwm} in a "high" state for the duration of duty cycle to_{ON}. Independent of the transfer cycle "reset" control signal V_c, the PWM controller **108** will either increase or decrease the duty cycle t_{ON} in response to a corresponding decrease or increase, respectively, in the voltage level of V_f; i.e., wherein the duty cycle t_{ON} of V_{pwm} is inversely proportional to the voltage level of V_f. Thus, operation of the control circuitry **104** is achieved as follows:

An auxiliary secondary winding T_{s2} of the transformer **96** supplies an auxiliary output voltage V_{aux}, by which the "main" output voltage V_o can be measured; i.e., by way of calculating from the selected turns ratio between secondary windings T_s and T_{s2}, respectively.

In accordance with a first aspect of the present invention, during each transfer of energy to the secondary, (i.e., when the switch **97** is turned OFF), current is passed through secondary winding T_{s2} which causes a feedback rectifying diode **121** to forward bias, wherein the current is stored in a feedback holding capacitor **123**, respectively. The (regulated) current discharged from the feedback capacitor **123** passes through a resistor bridge R_1, R_2, thereby generating the duty cycle feedback voltage V_f. In particular, the values of the resistors R_1 and R_2, respectively are preferably selected so that the resulting feedback voltage V_f will correspond approximately to a desired main output voltage V_o. Thus, if the main output voltage level V_o of the transformer **96** increases, (e.g., due to a decrease in the load across output port **50**), the auxiliary output voltage V_{aux} will cause corresponding increase in V_f. This, in turn, will cause the PWM controller **108** to decrease the duty cycle t_{ON} of V_{pwm}, thereby resulting in a corresponding decrease in the main output voltage V_o of the transformer **96**, i.e., due to the reduction in the amount of energy stored in, and released from, the transformer core T during each energy transfer cycle. The converse situation is also true; i.e., if the main output voltage V_o of the transformer **96** decreases, (e.g., due to an increase in the load across port **50**), the auxiliary output voltage V_{aux} will cause corresponding decrease in V_f, which, in turn, will cause the PWM controller **108** to increase the duty cycle t_{ON} of V_{pwm}, thereby causing more energy to be stored in, and released from, respectively, the transformer core T during each energy transfer cycle. This, in turn, will thereby increase the main output voltage level V_o of the transformer **96**.

In accordance with a second aspect of the present invention, at the beginning of each new transfer cycle period t_p, i.e., when V_{pwm} is set to "high" and switch **97** thereby turned ON, current drawn through the primary winding T_p is sensed by a current sensor circuit **120** interposed along input power path **95**. As current is drawn into the primary winding T_p, the current sensor emits a corresponding, (i.e., "ramp-up") current over a path **118**, thereby creating a non-zero voltage on **118**, which is summed at a node **110** with voltage over a second path **117** to form the transfer cycle period control voltage V_c. Thus, so long as the current flows through the primary winding T_p, control voltage V_c is non-zero, and the PWM controller **108** will not reset the transfer cycle period t_p.

When the switch **97** is turned OFF, (i.e., at the expiration of the current duty cycle t_{ON}, as regulated by V_f), the current (and voltage) over path **118** falls (rapidly) to zero. However, current passing through the auxiliary secondary winding T_{s2} creates a (slight) voltage differential over path **117**, between a pair of reverse-bias rectifying diodes **114** and **116**, respectively, so that the control voltage V_c through summing node **110** remains non-zero until the transfer current is completely discharged through T_{s2}; i.e., and V_{aux} falls to zero. At that instant, V_c also falls to zero, thereby causing the PWM controller **108** to begin a new energy transfer cycle period t_p by resetting V_{pwm} to "high" and turning ON switch **97**. By preferably selecting diodes **114** and **116** to have substantially identical characteristics, the voltage differential over path **117** is advantageously slight, e.g., equivalent to a high impedance input to the summing node **110**, and detection of the instant when the current has completely discharged through T_{s2} is relatively precise. In this manner, the energy transfer cycle period will advantageously closely track any changes in the output load, i.e., which will cause the amount of current drawn through the primary winding T_p over a fixed period of time to increase.

In order to prevent the current drawn through the primary winding T_p from saturating the transformer **96**, the current sensing circuit **120** preferably detects when the current level is approaching a threshold level and causes the PWM controller to switch V_{pwm} to a "low" state, and turn OFF switch **97**, respectively.

As can be observed, by way of the advantageous control circuitry **104**, the DC output voltage V_o may be maintained without overworking (i.e., distorting) the AC input signal back over the respective distribution cables **16** and **30**. In particular, the duty cycle t_{ON} of V_{pwm} and, thus, the ON time of switch **97**, is varied gradually over a frequency period of the AC input power signal **86**. In other words, if the output voltage V_o is low, the changes in the duty cycle t_{ON} will be increased proportionately until the average (i.e., target) output voltage level is achieved, and visa-versa.

Yet another advantage of this innovative applied topology is that the AC/DC power conditioning from the AC input **86** to the DC output **50** is accomplished in a single stage conversion, i.e., without requiring an initial input power factor correction. Because the RF communication signal has been removed by a respective diplexer circuit, (e.g., **56** or **74**, respectively, in the illustrated preferred embodiment), the transformer **96** may also advantageously provide voltage referencing with respect to the AC power input signal **86**.

Thus, a new and useful access coaxial access device for providing access to a high frequency RF communication signal and a source of operating voltage derived from a low frequency power signal, respectively, carried on a single coaxial distribution cable in a broadband communications network has been disclosed. While embodiments and applications of this invention have been shown and described, as would be apparent to those skilled in the art, many more modifications and applications are possible without departing from the inventive concepts herein.

For example, in an alternate preferred embodiment, (not illustrated), the distribution network **10** may include a subscriber network interface facility ("SNIF") at each subscriber premise location **18**, wherein the SNIF replaces the function of both the subscriber network unit **38** and the tap **44** of the illustrated embodiment; i.e., wherein the SNIF provides both telecommunication and CATV broadcast signals from the RF cable **34** to the respective subscriber premise location. With this alternate preferred embodiment, a respective CAD **32** would provide separate RF communication **34** and DC voltage **36** lines, respectively, to respective SNIF locations, i.e., instead of respective subscriber network units. An implementation of a subscriber network interface facility in accordance with such an embodiment is disclosed and described in U.S. patent application Ser. No. 08/608,436 filed Feb. 28, 1996, now U.S. Pat. No. 5,805,591, entitled "Subscriber Network Interface Facility", filed on the same date and assigned to the same assignees, respectively, as the present application, and which is fully incorporated herein by reference.

The scope of the disclosed inventions, therefore, are not to be restricted except in the spirit of the appended claims.

What is claimed:

1. An access device, comprising:

an input port comprising means for connecting to a first portion of a coaxial cable;

an output port comprising means for connecting to a second portion of said coaxial cable;

means for isolating an AC power signal from an RF signal;

a transformer for deriving a DC voltage from said isolated AC power signal, said transformer comprising a primary winding and a secondary winding; and

transformer control circuitry comprising

a switch, said switch alternately connecting or disconnecting said primary winding to a current source,

means for generating a switch control signal, said switch control signal having an independent duty cycle and transfer cycle period, respectively,

duty cycle control circuitry comprising means for increasing said duty cycle in response to a decrease in said DC voltage, and decreasing said duty cycle in response to an increase in said DC voltage, and

transformer reset circuitry comprising means for initiating an energy transfer cycle across said transformer in response to detecting the end of a previous energy transfer cycle.

2. The access device of claim **1**, further comprising means for splitting said isolated RF signal onto first and second internal RF paths.

3. The access device of claim **2**, further comprising means for combining the portion of said isolated RF signal on said first internal RF path with said isolated AC power signal, and for outputting said combined signals through said output port.

4. The access device of claim **2**, further comprising an RF output port connected to said second internal RF path.

5. The access device of claim **1**, further comprising a DC power supply port connected to said secondary winding.

6. The access device of claim **1**, wherein said means for isolating said AC power signal from the communication signal comprise a diplexer circuit.

7. The access device of claim **1**, further comprising an auxiliary port and means for selectively allow electrical and RF connection between said auxiliary port and said input port or said output port, respectively.

8. The access device of claim **1**, said duty cycle control circuitry further comprising means for generating a feedback voltage corresponding to said DC voltage.

9. The access device of claim **1**, said transformer reset circuitry further comprising an auxiliary transformer secondary winding, wherein said means for initiating an energy transfer cycle comprise a voltage control signal derived by summing a first voltage generated by current flowing through said primary winding with a second voltage generated by a current flowing through said auxiliary secondary winding, respectively.

10. The access device of claim **1**, wherein said transformer control circuitry further comprises a current saturation sensor, said sensor having means for interrupting said duty cycle upon detection of a threshold current level flowing through said primary winding.

11. In a broadband distribution network transporting a relatively high frequency RF signal and a relatively low frequency AC power signal, respectively, over a coaxial cable, an access device, comprising:

an input port comprising means for connecting to a first portion of the coaxial cable;

an output port comprising means for connecting to a second portion of the coaxial cable;

diplexer circuitry for isolating the AC power signal from the RF signal;

means for splitting the RF signal onto a first internal RF path and a second RF internal path, respectively;

an RF output port connected to said second internal RF path;

a transformer for supplying a DC voltage derived from the isolated AC power signal, said transformer comprising a primary winding and a secondary winding;

a DC power port connected to said secondary winding; and

transformer control circuitry comprising

a switch, said switch alternately connecting or disconnecting said primary winding to a current source,

means for generating a switch control signal, said switch control signal having an independent duty cycle and transfer cycle period, respectively,

duty cycle control circuitry comprising means for increasing said duty cycle in response to a decrease in said DC voltage, and decreasing said duty cycle in response to an increase in said DC voltage, and

transformer reset circuitry comprising means for initiating an energy transfer cycle across said transformer in response to detecting the end of a previous energy transfer cycle.

12. The access device of claim **11**, said transformer reset circuitry further comprising an auxiliary transformer secondary winding.

13. The access device of claim **12**, wherein said means for initiating an energy transfer cycle comprise a voltage control signal derived by summing a first voltage generated by current flowing through said primary winding with a second voltage generated by a current flowing through said auxiliary secondary winding, respectively.

14. The access device of claim **11**, wherein said transformer control circuitry further comprises a current saturation sensor, said sensor having means for interrupting said duty cycle upon detection of a threshold current level flowing through said primary winding.

15. The access device of claim **11**, further comprising an auxiliary port and means for selectively allow electrical and RF connection between said auxiliary port and said input port or said output port, respectively.

16. A coaxial cable access device, comprising:

circuitry for isolating an AC power signal from an RF signal carried over a coaxial cable;

a transformer for deriving a DC voltage from the isolated AC power signal, said transformer having a primary winding and a secondary winding; and

transformer control circuitry comprising

a switch, said switch alternately connecting or disconnecting said primary winding to a current source,

means for generating a switch control signal, said switch control signal having an independent duty cycle and transfer cycle period, respectively,

duty cycle control circuitry comprising means for increasing said duty cycle in response to a decrease in said DC voltage, and decreasing said duty cycle in response to an increase in said DC voltage, and

transformer reset circuitry comprising means for initiating an energy transfer cycle across said transformer in response to detecting the end of a previous energy transfer cycle.

17. The access device of claim **16**, said transformer reset circuitry further comprising an auxiliary transformer secondary winding.

18. The access device of claim **17**, wherein said means for initiating an energy transfer cycle comprise a voltage control signal derived by summing a first voltage generated by current flowing through said primary winding with a second voltage generated by a current flowing through said auxiliary secondary winding, respectively.

19. The access device of claim **17**, wherein said transformer control circuitry further comprises a current saturation sensor, said sensor having means for interrupting said duty cycle upon detection of a threshold current level flowing through said primary winding.

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